

## OBITUARY NOTICES OF FELLOWS DECEASED\*.

JAMES DAVID FORBES† was the youngest son of Sir William Forbes of Pitsligo, who was descended from the ancient family of the Forbes of Monymusk, on the banks of the Don, and was head of the well-known banking-house long established in the Parliament Square of Edinburgh. The mother of James Forbes was the only child and heiress of John Belches, afterwards Sir John Stewart, a cadet of the old house of Invermay. The early death of Lady Forbes, while her youngest son was a child scarce two years old, cast a sobering shade over his early years, and indeed coloured his whole life and character. His father idolized the child, as the last legacy of her whom he had lost. He retired from Edinburgh, and lived a secluded life, surrounded by his young family, in his country place of Colinton. There were spent James Forbes's childhood and boyhood. The teaching he got was of the most private, even desultory kind. Fear for the boy's health made his father nervously anxious lest he should overwork himself. So his education was left entirely to his sisters' governess, and to occasional lessons from the neighbouring village schoolmaster, a worthy man, to whom his distinguished pupil remained ever afterwards sincerely attached. But though lessons were easy, his mind was active, and by his twelfth year the natural bias towards physical knowledge was manifesting itself. Already his head was busy with mechanical contrivances,—a new velocipedometer, an anemometer, a metal quadrant made by his own hands for astronomical purposes. At the same time he was devouring every scientific book he could lay hands on, from the 'Nautical Almanac' to Woodhouse's 'Astronomy.' But all this devotion to science was kept strictly secret; he laboured at it in private, and said nothing, for his father would not have smiled on such pursuits. He would have objected to them both as too serious a tax on the young brain, and also as likely to turn him from the dry studies of the bar, for which he was destined. His own wish was to take orders in the English Church, to which he was strongly attached; but from this aim he was, not without reluctance, withdrawn by his father's expressed wish that he should study for the Scottish bar. This accordingly, from his fifteenth to his twenty-first year, was his ostensible purpose, but his heart was all the while turning secretly aside to the for-

\* Note to a passage in the Biography of M. Foucault, Proceedings of the Royal Society, vol. xvii.

It appears from a notice in the Report of the British Association for the Promotion of Science for 1843, that Dr. Joule had made an experiment demonstrating the conversion of work into heat, very similar to the experiment by M. Foucault described at the end of page lxxxiii.

† This notice of Professor Forbes, except what more especially refers to his scientific work, has been taken, with abridgement, but without other alteration in matter or language, from an inaugural address delivered by his distinguished successor, Principal Shairp, at the opening of the Academical Session of the United College, St. Andrew's, in 1869.

bidden paths of science. When he was only sixteen he began to keep a record, entitled "Ideas of Inventions;" because, as he expressed it, so many more ideas, chiefly mechanical, occurred to him than he could possibly execute; and, in order to remember these, he "resolved to write them down, taking most special care to distinguish between what were original and the parts which were borrowed." About the same time he began a journal of personal observations in astronomy, which he continued, with scarce an interruption, for seven years. He then also began to keep a meteorological journal, in which he recorded all his observations on the temperature and state of the atmosphere, with speculations as to their causes. The two last, especially, were continued for years. These were his real and earliest educators in science. By these he trained himself to be the patient and accurate observer which he ultimately became.

Thus entirely home-trained, and, indeed, self-educated, young Forbes entered Edinburgh University in Session 1825-26, and joined the Classes of Latin and Chemistry. About the close of his first year at College he entered on another phase of his self-education, which was destined to have important results. He commenced an anonymous correspondence on scientific matters with the late Sir David Brewster. The lad of seventeen wrote to the then renowned man of science, offering him for insertion in his well-known 'Philosophical Journal' a paper containing an attempt to account for the apparently infinite number of the stars. The paper was not only inserted, but the following words were annexed to it: "We should be glad to hear again from the author of this article, and, if possible, learn his address." The first part of this request was readily complied with. For several years hardly a Number of the journal appeared without some paper either of original observation, experiment, or cautious speculation from the young votary of science. The latter part of the request he was more slow to meet; all the communications still bore the original signature, or " $\Delta$ "—a disguise which the author's modesty induced him to assume, and which Sir David tried to pierce for some years in vain. Those who are best versed in these subjects will, I believe, most appreciate the natural insight, careful toil, and patient observation embodied in those papers, written at seventeen, with none to help or consult with, indeed, in the utmost secrecy. Towards the end of 1826 the young student's College course was interrupted (but his philosophical correspondence was not) by a year spent in Italy with his father and family. With his passion for science in no degree abated, he entered into all that Italy contains to feed the imaginative and historic mind, almost as fully as if he had been exclusively a scholar or man of letters—so early appeared that fine blending of literary taste with scientific exactness which in after years lent to his lectures and his writings so great a charm. The 'Philosophical Journal' contained some fruits of his Italian experiences, in what Sir David styles " $\Delta$ 's very excellent set of observations," made at Rome, on the climate of Naples, and on the phenomena of Mount Vesuvius. These three papers appearing in successive Numbers of the Journal,

called forth much attention from scientific men. On his return home to Colinton, in the autumn of 1827, his diary records that he is pleased "to see Brewster's journal, and read the articles of mine he inserted in October last on the apparent number of the stars, the heats and colds of last year, and elements of the lunar eclipse, together with all the other papers which I have sent, inserted, or favourably noticed." In the correspondence with Brewster, the disguise of  $\Delta$  was preserved to the close of 1828. Many and curious were the attempts Sir David made to pierce behind the mask and see the real face of his unknown contributor. In one of his letters he says :—" We who have begun our downward course look anxiously for some rising stars ; but, excepting yourself and Mr. F., I know of no young men who are likely to extend the boundaries of science." Who was Mr. F.? Was he the same as the unknown  $\Delta$ ? When at length the mask was withdrawn, the welcome which the elder philosopher gives to his younger fellow-labourer is highly characteristic. He expresses his joy " that Scotland possesses one young man capable of pursuing science with the ardour and talent of  $\Delta$ , and that he belonged to a family for which he had so much esteem and affection." He then goes on to advise him to allow no professional duties to turn him from science ; he would find in it a solace and delight amid the bustle and vexations of life.

Though thus early launched into original inquiries, James Forbes was still only a Student of Arts in Edinburgh University. The excitement of young and successful authorship seems never for a moment to have turned his head, or to have made him bate one jot the patient industry by which only college classes can be turned to account. In the Moral Philosophy Class, which he attended after returning from the Continent, we find him preparing with great labour an essay of sixty large quarto pages for Professor Wilson. The essay was on the influence and advantages of the study of astronomy on the mind, and it was accompanied by scientific illustrations and notes. This and other essays of the young physicist so far commended themselves to the Professor of Ethics, that at the close of the Session he made him Medalist in the Class, and ever afterwards received him to intimate friendship.

The month before James Forbes entered the Class of Natural Philosophy an event happened which deeply impressed him. His father was removed by death, and this was soon to be followed by the breaking of the old home at Colinton House. This bereavement formed a turning-point in his life, and deepened his already religious character. Solemnized, yet braced, he entered on the Natural Philosophy Class, then taught by the celebrated Sir John Leslie, in his later years. In the subjects of that Class lay his own specialty, but he had never received one word of mathematical instruction from any one, all his mathematics were entirely self-acquired. Yet, notwithstanding this disadvantage, in the competitions with students who had passed through a regular Mathematical Course he held the first place, and closed the Session by easily bearing off the highest honours. While he was

a Student in the Natural Philosophy Class he had the honour of being proposed by Sir David Brewster as a Member of the Royal Society of Edinburgh before he had reached his twentieth birthday.

Though his College course may be said to have been now completed, he took yet another Session, attending Sir John Leslie's Class, and the Chemistry Class of Dr. Hope each for the second time, and combining with these two the study of the Law. At the close of his College life, in April 1830, he looks back on it, in his diary, "with peculiar satisfaction, as comprising the happiest period of his life." That summer (1830) he passed his Law trials, and put on his advocate's gown, but never wore it. To his great joy, having obtained the full concurrence of his family and friends, he cast law for ever behind him, and, content with a small competence, gave himself unreservedly to science. This resolution was not taken hurriedly. But his mind once made up never faltered. At the beginning of next winter he says:—"I now enter on the delightful and engrossing studies, which have now, blessed be God, become my principal and legitimate object, untrammelled by jarring occupations and conscientious scruples. He then gave himself to closer study of the higher mathematics, and at the same time began those experiments on heat which were afterwards to result in one of his best scientific achievements. A hint of his future destiny was at this time given him. He had happened to go to hear Sir John Leslie's opening lecture in that Professor's last Session but one, 1830-31. At the close of the lecture Sir John, who had never before admitted his promising Student to any special intimacy, sent for him, and, after asking him about his own studies, told him that when he (Sir John) proposed going to the East last summer, he had thought of getting him (James Forbes) to officiate for him, but was afraid the public might think him too young. He then broke off abruptly. In exactly two years from this time young Mr. Forbes, who had gone to the Continent on a long scientific tour, was recalled by the news of Sir John Leslie's death, and that his friends in Scotland had given in his name as a Candidate for the vacant Chair. Then ensued a contest, not the least memorable of those many contests of the same kind by which Edinburgh has made itself conspicuous. Two things made this one especially warm, and even painful. By one of those strange turns in men's destiny, Mr. Forbes's chief opponent was his friend and patron, Sir David Brewster, now almost a veteran in the army of science. Political feeling, too, was added. It was the era of the Reform Bill, and party spirit, then running high in Scotland, as elsewhere, entered as an element of the contest even more than it usually does. Mr. Forbes, though only twenty-three, was elected by a very decisive majority; and, however it may have appeared at the time, the result, we know, justified the wisdom of the choice. It is pleasing to be assured that, whatever passing feeling the contest may have awakened, the old intimacy was soon renewed, and the friendship so honourable to both these distinguished men continued unimpaired till the close of their lives.

He thus entered on a Professorate of seven-and-twenty years, carried on with an energy and success rarely equalled, never surpassed. He began to teach the Natural Philosophy Class in Session 1833-34, when he was only four-and-twenty, yet from the very first he rivetted the attention of one of the largest and most distinguished classes of students that Edinburgh University ever contained. One great feature of his teaching, as I have always understood, was that while it stimulated the powers and won the admiration of his most scientific listeners, he yet made himself attractive to all students who were intelligent, though less highly gifted.

In these lectures the whole range of Natural Philosophy was gone through, and the laborious and well-sustained study required for the due performance of his professorial work had doubtless prepared him for the task, which he successfully accomplished, of writing the well-known "Dissertation on the Progress of Mathematical and Physical Science, principally from 1775 to 1850," which was published in the last edition of the 'Encyclopædia Britannica.' Meanwhile, however, Professor Forbes was indefatigable in original investigation, for which he had so early shown an aptitude; and the separate titles of his contributions to Transactions of Societies and Scientific Journals, as given in the Royal Society's 'Catalogue of Scientific Papers,' amounted in 1863 to one hundred and eighteen. These embrace various subjects belonging to Physics, Meteorology, Geology, and Physical Geography. The most important of his earlier experimental investigations was that in which he succeeded in demonstrating the polarization of heat. Melloni had been pursuing an inquiry in the same direction, but had failed to obtain the result he was in quest of. Professor Forbes was more fortunate. The steps of his investigation are thus stated by himself in the dissertation above referred to.

He says:—"I have just referred to my own early experiments on the subject (which were likewise inconclusive), in order to explain that it was natural, on hearing of the application of the thermo-multiplier to measure radiant heat, that I should wish to repeat them with the new instrument. This I did in 1834. I first succeeded in proving the polarization of heat by tourmaline (which Melloni had announced did not take place), next by transmission through a bundle of very thin mica plates, inclined to the transmitted ray, and afterwards by reflexion from the multiplied surfaces of a pile of thin mica plates placed at the polarizing angle. I next succeeded in showing that polarized heat is subject to the same modifications which doubly-refracting crystallized bodies impress upon light, by suffering a beam of heat (even when quite obscure), after being polarized by transmission, to pass through a depolarizing plate of mica, the heat traversing a second mica bundle before it was received on the pile. As the plate of mica used for depolarization was made to rotate (in its own plane), the amount of heat shown by the galvanometer was found to fluctuate just as the amount of light received by the eye under similar circumstances would have done. This experiment, which, with the others just mentioned, was soon repeated and confirmed by other observers, still remains the only one proving

the double refraction of heat unaccompanied by light ; and, though somewhat indirect, it will hardly be regarded by competent judges as otherwise than conclusive. Iceland spar and other doubly-refracting substances absorb invisible heat too rapidly to be used for affecting *directly* the separation of the rays, which requires a very considerable thickness of the crystal. I also succeeded in repeating Fresnel's experiment of producing circular polarization by two internal reflections. The substance used was, of course, rock-salt."

For these researches the Royal Society awarded to their author the Rumford Medal, in 1838. Taken in conjunction with the experiments of Melloni on the absorption, &c. of radiant heat, they afforded the conclusive proof of the *identity* of thermal and luminous radiations,—a fact of the very greatest consequence to the further progress of one of the most fascinating branches of physical science.

In 1842 Professor Forbes communicated to the Royal Society a paper "On the Transparency of the Atmosphere, and the Law of Extinction of the Solar Rays in passing through it," which was adopted as the Bakerian Lecture for that year, and for which in 1843 he received a Royal Medal.

Another prominent work of Forbes is that long series of observations on the Nature and Motion of Glaciers, which he pursued with intense application, and, as there is too good reason to believe, to the serious injury of his health. He had spent several vacations on the Continent, and had wandered over the mountains of Switzerland and Savoy, studying the Geology and Physical Geography of those regions ; but he specially devoted the summers of 1842–44 and 1846 to the exploration of the glaciers of the Alps. Into this pursuit he threw an enthusiasm and concentration of energy which few men are capable of. In 1843 appeared his well-known work, 'Travels in the Alps,' in which he blends interesting descriptions of scenery with scientific observations and reasonings ; and the fruits of his earlier labours on the glaciers are there given. Shortly before this he commenced the interesting series of sixteen "Letters on Glaciers" published in the 'Edinburgh New Philosophical Journal' from 1842 to 1851, which contain the results of his continued study ; and he also set forth and discussed his views on the constitution and motion of glaciers, in an elaborate Memoir published in the Philosophical Transactions for 1846, entitled "Illustrations of the Viscous Theory of Glacier Motion."

Not contented to limit his observations to Switzerland and Savoy, he in 1851 made an excursion to Norway to study the glacier phenomena of that country, and gave an account of his work in 'The Glaciers of Norway visited in 1851,' which was published in 1853.

Professor Forbes looked on the progressive motion of a glacier as comparable to that of a plastic mass, moulding and adapting itself to the variations in the width and depth of its channel and the inclination of its bed, and moving faster in the middle than at the sides, as would happen with such a yielding substance. A view substantially similar had been previously promulgated by Bordier in 1773, the contemporary of De Saussure, and more

recently by M. Rendu, then Canon, afterwards Bishop of Annecy; but to Forbes belongs certainly the merit of proving its general truth by careful and prolonged experimental measurements of the rate of progression of glaciers at different parts. But whilst it is plain that the ice of a moving glacier behaves in the gross like a plastic substance, there has been a question by what intestine changes or motions of its particles its change of figure is brought about or accompanied; and later inquirers maintain that the ice yields by breaking up into minute fragments, which speedily reunite by partial melting and regelation, thus permitting of change of form in the mass. The ribboned or veined structure of glacier ice, which had been but little attended to by previous writers, was carefully studied by Forbes. Having seen that the velocity of movement increases from the sides to the middle of the glacier, he ascribed the production of the ribboned structure to "differential motion" between adjacent laminar sections of its substance, a process which has since been termed "shearing." Others have compared the phenomenon to the lamination of slaty rocks now very generally regarded as caused by pressure in a direction perpendicular to the planes of lamination.

But while there may be difference of opinion as to the physical explanation of the observed phenomena, there can be no question of Forbes's signal merit in connexion with the scientific history of glaciers; and it is pleasing to know that it was generously acknowledged in his lifetime by a distinguished rival in the same field, who thus speaks of him\*:—"The more his labours are compared with those of other observers, the more prominently does his comparative intellectual magnitude come forward. The speaker would not content himself with saying that the book of Prof. Forbes was the best book which had been written on the subject. The qualities of mind, and the physical culture invested in that excellent work, were such as to make it, in the estimation of the physical investigator at least, outweigh all other books upon the subject taken together."

While Switserland was the main region of Forbes's explorations, he did not neglect his own land. In the summer of 1845 he traversed the rugged hills of Skye, and proved that the bare scarps of the Cuchullius had been ground down by the same kind of glaciers as those which are now wearing down the gorges of the Alps.

The last important scientific labour he was permitted to undertake was on the subject of thermal conductivity. He was the first to point out—and this at a very early period of his career—the fact that the conducting-powers of the metals for electricity are approximately proportional to their conducting-powers for heat. Now, heat diminishes materially the electric conducting-power—does it also affect the thermal conductivity? Forbes showed that (at least in the case of iron, the only metal his failing health left him strength to examine) *the conductivity for heat diminishes as the temperature increases*. Another result of the same investigation, and one

\* Report of a Lecture delivered by Professor Tyndall at the Royal Institution, June 4, 1858.

of great interest and importance in modern science, is his determination (the earliest of any real value) of the *absolute conductivity* of a substance, i. e. *how much* heat passes per second per unit of surface through an iron plate of given thickness, whose faces are maintained at constant given temperatures. As a proof of the value attached by scientific men to these ingenious experiments, it is only necessary to mention that the British Association has given a grant for their repetition with the best attainable instrumental means, and for their extension to other substances than that to which Forbes was obliged to confine himself.

But on his more active work an arrest was soon to be laid. In December 1851 he was prostrated by a severe hemorrhage in the lungs, occasioned, it was thought, in part by exposure on the Alps, in part by too close application while prosecuting further experiments on heat. For two Sessions and a half he was entirely laid aside from work. In the winter of 1854 he resumed his duties, but daily lecturing was a heavy burden on his now enfeebled strength. As for exploration or continuous experimenting, all that was ended.

"Though he could not leave Edinburgh without some natural pangs, yet," continues Principal Shairp, "it was no doubt a relief to him when he was called to assume the Principalship of this College [St. Salvador and St. Leonard's United College, St. Andrew's] in the beginning of Session 1859-60. The office fitted in better to his state of health, because it relieved him from the necessity of giving daily lectures, and set him more free to do his work at the hours and in the way that suited him. He was, however, far from regarding it as a sinecure, as some speak. Our late Principal was not the man to regard any post of trust as a sinecure. He came among us, no doubt, with diminished strength. But illness had not abated his mental energy. Few men felt more the appeal which the past history and present aspect of this city makes to the imagination. But though much captivated with this, he found on his arrival enough of hard matter-of-fact work ready to his hand, and into it he threw himself vigorously."

"Those who were comparatively strangers to our late Principal observed in him a certain antique formality and reserve which they sometimes mistook for coldness. They little knew how gentle and affectionate a heart lay under that exterior—what longing for sympathy, what appreciation of confidence and frankness in others. His thoroughness in all work, his painstaking in the most ordinary college business, his patience in getting to the bottom of every minutest detail—as great, indeed, as if it had been a link in some grave discovery—these are things which only his colleagues can know."

"His last public act, I believe, was to preside at the laying of the foundation-stone of the new College Hall Building in 1867. A few days after, he left St. Andrew's not to return. The sequel in its outward details (that winter abroad, the return to Clifton, and the close) would be too painful to dwell on. But while his body was reduced to the last stage of

weakness, his mind remained self-controlled, unclouded, and peaceful to the end. He departed on the last day of the departing year (1868), upheld by humble faith in Him to whom long since he had committed himself."

Professor Forbes was a Vice-President of the Royal Society of Edinburgh, and a Corresponding Member of the French Institute. His election into the Royal Society is dated June 7, 1832.

JOHANN EVANGELISTA PURKINJE was born in the town of Libochowitz, near Leitmeritz, in Bohemia, on the 17th of December, 1787. He obtained the first rudiments of education in the school of Libochowitz. He then went to Nicholsburg in Moravia, where he passed through the normal school and Gymnasium with credit, and entered the Order of the Piarists with the intention of becoming a teacher. After a noviciate of one year at Kaltwasser in Moravia, he was sent to Stráznice in Hungary as teacher in the Gymnasium of that place. In 1805 he began to study French and Italian, and also the language and literature of Bohemia. In the following year, while officiating as teacher in the normal school at Leutomischlin in Bohemia, he turned his attention to the writings of the German philosophers, and especially to those of Fichte. These pursuits opened out to him the prospect of a higher intellectual culture, which he felt to be within his reach. He accordingly quitted the school and became a student in the University of Prague, and supported himself by taking pupils. After some hesitation, he adopted the career of medicine. For two years he pursued his studies in the Anatomical Institute under Dr. Ilg, and for two more in the surgical division of the hospital under Dr. Fritz, by whom he was greatly esteemed. During this time he derived the means of living from the family of Baron Hildebrandt, to whose son he had been tutor. In 1818 he graduated as M.D., the title of his inaugural dissertation being, "Contributions to our Knowledge of Subjective Vision." In this dissertation he explained how some properties, and even some structural relations of the eye, can be investigated by means partly psychological, partly physiological, which otherwise require for their discovery the most minute microscopical examination. This essay decided his line of research; it opened a new world to his fellow-labourers, and won for himself the approbation of Göthe, who was engaged in similar pursuits. Shortly afterwards he became assistant to the Professors of Anatomy and Physiology, Ilg and Rottenberger. In 1820 Purkinje published in the '*Medicinische Jahrbücher des österreichischen Staates*,' a paper on Vertigo, from observations made upon himself. In 1822 he was appointed to the Professorship of Physiology in the University of Breslaw, on the recommendation of Dr. Rust, of Berlin. At Easter in 1823 he entered upon his duties at Breslaw. In consequence of prejudice against Austrians on the part of the Medical Faculty, and a desire for the appointment of another person, he was not well received at first, but in the course of two years he overcame all dislike by the extent of his acquirements, and his urbane and unassuming demeanour. The inaugural disser-

tation required of the newly-appointed Professor had for its title, "*De examine physiologico organi visus et systematis cutanei.*" In this dissertation he described the now well-known method of investigating the structure of the retina by the appearance seen after waving a flame beside the eye. He followed out this subject in a work entitled "*Observations and Experiments on the Physiology of the Senses, or new Contributions to the Knowledge of Subjective Vision,*" published in 1825. In the course of the same year the Faculty of Medicine of Breslaw resolved to send their congratulations to Blumenbach on the fifteenth anniversary of his doctorate, accompanied by an original memoir on a suitable subject. Purkinje's offer to write the memoir was gladly accepted. He took for his subject the elementary origin of the bird's egg within the ovary, and its subsequent progress up to the time of its deposition. This investigation, which occupied him for three months, resulted in one of the most important physiological discoveries of his time, that of the germinal vesicle, now generally known as the "*vesicle of Purkinje.*" The congratulatory memoir in which it was first described and figured was afterwards published independently under the title of "*Symbolæ ad ovi avium historiam ante incubationem,*" 1830. In 1828-30 he entered upon a microscopical examination of the organization of plants. The elastic fibres of various vessels of plants, and the receptacles of pollen and seed capsules, which scatter the pollen and the seed, especially attracted his attention. The account of these researches was published in 1830: "*De cellulis antherum fibrosis nec non de granorum pollinarium formis, commentatio phytotomica.*"

On the recommendation of Mirbel, the Monthyon Prize was awarded to him by the French Institute for this essay. In the spring of 1833 he undertook the observation of the development of the tadpole through its various stages. He carefully examined the cilia which at first cover the whole body, then the head, and lastly only the branches of the gills. In the course of the same year Professor Valentin began his researches on the organization of the ovum of mammals, and while examining the funnel of the oviduct of a rabbit, observed a movement of a granule on the mucous membrane of the oviduct while floating in water, and attributed it to spermatozoa. But Purkinje traced the motion to cilia on the edge of the membrane. This discovery of ciliary motion in a warm-blooded animal led to a joint research, and to the publication of the work '*De phenomeno generali et fundamentali motus vibratorii continui in membranis cum externis tum internis animalium plurimorum et superiorum et inferiorum ordinum obvii, commentatio physiologica,*' 1835.

On entering upon his duties at Breslaw he established a physiological institute in his own house, where students were furnished with the means of examining microscopically the elementary parts of human bodies and those of animals, and of drawing and accurately describing them. These researches supplied the materials of a series of academical dissertations, many of which disclosed new methods of microscopical investigation, a field of research then beginning to be generally cultivated after having been

comparatively neglected since the days of Malpighi, Swammerdam, and Leeuwenhoek. Others again treated of various physiological or anatomical subjects. In the first of these essays, by Krauss, in 1824, "*De cerebri læsi ad motum voluntarium relatione, certaque vertiginis directione ex certis cerebri regionibus læsis pendente*," by the introduction of his theory of vertigo, he confirmed and extended the discoveries of Flourens and Magendie respecting the activity of the cerebrum and cerebellum. In another, by Wendt, in 1833, he announced the important discovery of the sudorific glands and their excretory ducts in the human skin. In another work of this description, '*De penitiori ossium structura observationes*' (1834), by Deutsch, also in '*De penitiori dentium humanorum structura*' (1835), and in '*Meletemata circa mammalium dentium evolutionem*' (1835), by Raschkow, new discoveries made by Purkinje are announced. These were followed by '*De penitiori cartilaginum structura symbolæ*' (1836), by Meckauer, '*De arteriarum et venarum structura*' (1836), by Räuschel, '*De genitalium evolutione in embryone feminino observata*' (1837), and '*De musculari cordis structura*' (1839). In the essay entitled "*De formatione granulosa in nervis, aliisque partibus organismi animalis*" (1839), Purkinje, in opposition to the views of Remak and others, maintained that the "*formatio granulosa*" or elongated corpuscles resembling cell-nuclei, which are found attached to the sympathetic nerves, are not peculiar to this system, and that they consist of a newer material resembling protoplasm, out of which the more matured portions derive their growth. In the essay '*De velamentis medullæ spinalis*,' he made known the discovery of a peculiar nervous plexus distributed on the pia mater of the spinal cord, which can be easily exhibited by maceration in acetic acid. An account of these observations and of the existence of nerves in other membranous parts was given in a memoir (in Polish) published in the Year-book of the Medical Faculty of Cracow, and reproduced in German, with additions, in Müller's '*Archiv*' for 1845. Two other dissertations appeared, the titles of which were, '*De structura uteri non gravidi*' (1840), and '*De numero atque mensura microscopica fibrarum-elementarium systematis cerebrospinalis symbolæ*' (1845).

Purkinje having at length succeeded in convincing the Government of the necessity of establishing an independent institution for teaching physiology, a house was built in 1842 for the purpose of carrying on physiological researches, and a suitable grant made for defraying the stipends of assistants and other expenses. This example has since been followed in all the German and Austrian universities.

Purkinje was the author of a paper "*On the World of Dreams*," in '*Hesperus*' (1821), "*On the Physiological Import of Vertigo*" in Rust's *Magazin* (1827), "*On Tartini's Tones*," in the *Bulletin of the Natural History Section of the 'Schlesisch-patriotischen Gesellschaft'* for 1825, and '*An Auscultation Experiment*,' in which, by means of an instrument of his invention, the points of rest and motion of a vibrating plate can be de-

terminated by hearing alone, without the employment of sand, as in Chladni's experiment.

In Müller's 'Archiv für Anatomie und Physiologie' for 1834 he described a compressorium for microscopic observation invented by himself, which soon came into general use, and soon afterwards published, conjointly with Valentin, an account of researches on ciliary movements observed in the cavities of the brain. In 1838 followed his interesting experiments, in conjunction with Pappenheim, on artificial digestion. In 1845, as already stated, the same journal published his observations on the nerves. Purkinje is also the author of many valuable articles in the 'Encyclopädisches Wörterbuch der Medicinischen Wissenschaften,' and Wagner's 'Handwörterbuch der Physiologie;' of about sixty papers and lectures in the publications of the 'Schlesisch-patriotischen Gesellschaft' of Breslaw, of physiological papers (in Polish) in the scientific journals published in Cracow, of reviews and articles on the Slavonic languages and literature. He translated Tasso's 'Gerusalemme Liberata,' many of Schiller's poems, and all his Lyrics into Bohemian.

At the Naturforscherversammlung, held at Prague in 1837, he anticipated Schwann in the announcement of the doctrine of the identity of fundamental structure of plants and animals, but with this distinction between the two cases, that he calls the elements of plants and those of animals, cells and granules respectively.

In 1848 he attended the Meeting of the Slavonic races in Prague, and was present at the celebration of the five hundredth anniversary of the foundation of the University, when the Degree of Doctor of Philosophy was conferred on him. A long-cherished wish to be enabled to pass the remainder of his days in his native country was gratified by his nomination to the Professorship of Physiology in the University of Prague in the summer of 1850. His first care was the due equipment of the Physiological Institute, at that time recently established. This he effected in a satisfactory manner in the course of a year. His next endeavour was to promote the cultivation of the Natural Sciences among the Bohemian-speaking population, and with this view he became one of the editors of the Natural-History Journal 'Ziva' from 1853 to 1864, and also contributed many articles to the Journal of the Bohemian Museum.

One of the most important of his later researches was a careful investigation of the sound perceived in the interior of the skull. On examining the inmates of a deaf and dumb asylum, he found, as some previous observers had discovered, that almost all possess the power of hearing through the skull.

His election as a Foreign Member of the Royal Society took place in 1850. He was corresponding Member of the French Institute, Member of the Academies of Vienna, Berlin, and St. Petersburg, and of many other learned Societies. He retained his vigour of body and mind up to the last days of his life. His death, after an illness of no long duration, on the 28th of July, 1869, was mourned by every class of Society in Bohemia.

SIR JAMES CLARK was born at Cullen in Banffshire in December 1788, and was educated at the parish school of Fordyce, and subsequently at the University of Aberdeen. In 1806 he entered a writer's (solicitor's) office at Banff; but, not liking the law, he was given the choice of the Church, with the promise of a ministry, or the profession of medicine. He chose the latter calling, and proceeded to Edinburgh. In 1809 he passed at the College of Surgeons, and then entered the medical service of the navy. He served at Haslar Hospital till July 1810, when he was sent to sea as Assistant-Surgeon in the schooner 'Thistle,' which was going with despatches to New York. The 'Thistle' was wrecked, with the loss of several of her crew, on the coast of New Jersey, and the survivors lost everything they possessed, and suffered great privations. On returning to England he was promoted to the rank of surgeon, and joined the 'Collobrée.' It is remarkable that this vessel was also wrecked on the American coast. He was then appointed to the 'Chesapeake,' which had been recently taken by Sir Philip Broke, in his famous action, and served in her until 1814, when he was transferred to the 'Maidstone.' In this ship he met with and formed a strong friendship for Lieutenant (afterwards Sir Edward) Parry, the celebrated Arctic navigator, and made, in conjunction with him, a series of experiments on the temperature of the Gulf-stream. During his service in the navy his attention appears to have been strongly directed to the question of climate, and the few notes he has left of this period of his life chiefly refer to observations he made on this subject, and to the hygienic conditions influencing the health of the men under his charge.

In 1815 the 'Maidstone' returned to England to be paid off, and Sir James Clark was placed on half pay. In 1816 he went to Edinburgh, where he attended the University Classes, and graduated as M.D. in 1817.

In 1818 he was asked to accompany a gentleman far advanced in consumption to the south of France. He went with his patient to Marseilles, Hyères, Nice, and Florence, during the winter and spring, and in the summer to Lausanne. It was owing to this charge that his attention was especially drawn to the effect of climate on consumption, and that he commenced the collection of meteorological and climatic data, with a view of studying their influence on that disease.

In 1819 he settled in Rome, where English families were beginning to congregate, and remained there until 1826, when he removed to London.

During his residence at Rome he spent the summers in visiting the medical schools and the watering-places of Italy, France, and Germany, and continued his studies on climate. In 1820 he published a small work, entitled "Notes on Climate, Diseases, Hospitals, and Medical Schools in France, Italy, and Switzerland," which formed the foundation of a subsequent larger work on the 'Sanative Influence of Climate.' In the same year he was married to Miss Stephen, the daughter of the Rev. Dr. Stephen, Rector of Nassau, and Chaplain to the Forces at New Providence. In

1826, being partly urged to the step by his friends, and partly influenced by consideration for his wife's health, he left Rome; and after a few months spent in visiting the chief medical institutions of France and Germany, and the Pyrenean and German baths, then very little known in England, he settled in London. In the autumn of 1827 he was attacked with typhoid fever, and was ill for several months. He never recovered perfectly from this attack; it left a delicacy of digestion behind it, and permanently enfeebled him.

Soon after settling in London, Prince Leopold, afterwards King of the Belgians, whose attention had been called to him by his investigation of the German waters, appointed him his physician, and this subsequently (in 1834) led to his appointment as physician to the Duchess of Kent.

In 1829 he published his larger work on the 'Sanative Influence of Climate.' This work, which was long considered the standard book on climate, and went through several editions, has had a very wide influence, not only on medical practice, but on the collection of meteorological and other data respecting climatic conditions. He subsequently (1832) published articles on air and climate in the 'Cyclopædia of Practical Medicine.'

In the autumn of 1829 Prince Leopold, who was then engaged in the negotiation which resulted in his refusal of the crown of Greece, offered, if he accepted the crown, to take Dr. Clark to Athens; but this he declined.

He was elected a Fellow of the Royal Society in 1832, and in 1835 published his 'Treatise on Consumption and Scrofula,' which, as well as the work on climate, was translated into Italian, German, and French, and passed in this country through several editions.

Soon afterwards he wrote an article on tubercular phthisis in the 'Cyclopædia of Practical Medicine.'

Two years subsequently, on the accession of Her Majesty, he was appointed Physician in Ordinary, and subsequently received a similar appointment to Prince Albert.

From this time the life of Sir James Clark (he was made a baronet in 1838) was spent in the discharge of his responsible duties as medical adviser to the Court, and in the fatigues of a London practice. It was therefore impossible for him to continue his scientific observations on climate, or even to prosecute further his more purely professional inquiries. But indirectly, in this latter period of his life, he lent a most powerful aid to science.

He was always ready to help, and to use his influence, which yearly became greater, both with the Court and with the leaders of parties, for the furtherance of scientific objects, and for the advance of education. It is difficult to give a complete account of what he did in this direction, as he has left no records. He was, indeed, singularly indifferent to the recognition of his services, and, provided the end was gained, did not desire that his share in it should be known. But his chief influence appears to have been directed to the improvement of medical and of general education,

to fostering special scientific instruction, to the promotion of sanitary measures, to the improvement of the Lunacy Laws, and of the public medical services.

He appears to have always taken a deep interest in medical education. Early in life he had published in Italian a work addressed to Professor Tommasini on English medical literature, and some time afterwards he published some 'Observations on the System of Teaching Clinical Medicine in the University of Edinburgh, with suggestions for its improvement.' He had also corresponded with both French and Italian physicians on this point; and in the summer of 1825 he had spent several months in Paris for the purpose of observing the method of clinical teaching followed by Laennec.

When, therefore, in 1838 the University of London was founded, and he was asked to serve on the Senate, he was fully prepared to deal with this subject of medical education; and it is to a considerable extent to his labours at that time, and subsequently, when further changes were made in the curriculum, that the present examining system of the Medical Section of the University owes its shape. The leading features of the scheme which, in consultation with experienced medical teachers, he adopted, and which he advocated in the Senate, were to require evidence of a certain time having been spent in the study of medicine, but not to demand or to rely on many certificates of attendance, but to trust to a searching examination; to split up the examination into two (and subsequently into three) parts, to be undergone at different stages of education, and to make the examination as practical and as thorough as possible. Clinical examinations were not, however, at first employed, but he subsequently obtained the introduction of this important part of medical examination.

He continued to serve on the Senate until 1865, when he resigned, to the great regret of his colleagues.

In 1854, when the Government determined to open the Indian medical service to unrestricted competition, he was requested to organize the method of medical examination. He did so, and gave this examination the form which, with a slight alteration, it has since retained. In this examination he recommended the introduction of practical surgical and medical tests; and to this may be traced much of the improvement which has taken place of late years in all parts of the kingdom in practical medical teaching.

In 1858 he was appointed by the Crown a Member of the General Council of Medical Education which was constituted under the Medical Act of that year. He served on this body till December 1860.

In connexion with medical education, he interested himself on the subject of Medical Reform, and in 1842 and 1843 he wrote two letters to Sir James Graham on that subject. The second letter, which gives a *résumé* of the first, urges the need "for a good and uniform system of medical education," which he says should be the same throughout the empire for every medical practitioner. He then sketches the constitution of a body

to whom ought to be delegated the power of carrying out the principles of education to be laid down by the Government. He had evidently formed an idea of a General Medical Council, which may yet some day be turned to account.

He did not, however, restrict his labours to medical education. He took a deep interest in the improvement of the Universities generally, and assisted Prince Albert in the projects which eventually ended in the alterations in the Universities of Cambridge and Oxford. At a later date he was very active in aiding the reconstruction of the University of Aberdeen.

His greatest attempt to improve purely scientific education was made in connexion with the College of Chemistry. He was deeply impressed with the defective opportunities of studying practical chemistry in this country as compared with Germany, and with the unfavourable influence that deficiency would have, not only on our scientific standing, but on our powers as a manufacturing nation. The influence of Liebig's doctrines on agricultural chemistry and on the improvement of the productive powers of soil were also at that time attracting great attention in England, and impressed him greatly with the importance of cultivating this subject. Whether the State should or should not more or less assist the teaching of pure science, or should leave this to the independent exertion of institutions or private individuals, is a matter which need not be here discussed. Sir James Clark's opinion appears to have been that the Continental system of State aid had the effect of overweighting England in the race, and that if we wished to maintain our equality in science, we had no option but to imitate to a certain extent the Continental plan. The College of Chemistry, however, in the first instance, was intended to be self-supporting. It was commenced in 1845 by Dr. Gardner; and Sir James Clark soon became one of its most active supporters, and through his influence Prince Albert interested himself greatly in it.

In the summer of that year, when the Queen and Prince were in Germany, Professor von Liebig was requested by Sir James to name some chemist who could carry on in England the same kind of practical instruction which had made Giessen so famous. Liebig mentioned three names, and fortunately circumstances led to the selection of Dr. Hofmann. Through the influence of Prince Albert, Dr. Hofmann obtained leave from the University of Bonn for two years, and soon afterwards the College of Chemistry was opened.

How successful it was in a scientific point of view, even from the first, needs no record; but its expenses were heavy, and perhaps the College might even have been closed from pecuniary failure about the year 1852 had not the Prince Consort, urged on by Sir James, so exerted his influence that the Government consented to give a small assistance, and at length the College of Chemistry eventually became incorporated with the Royal School of Mines. Since that time the College (which is partly self-supporting) has done much to diffuse among our manufacturing and agri-

cultural population a knowledge of Chemistry, and to advance the science by original research. It is to be regretted, however, that the College of Chemistry, originally established as an independent institution, self-supporting, or aided, if necessary, by private means, could not maintain itself on that footing.

As far as possible also Sir James Clark gave a warm support to all plans for promoting the study of Natural History, and was ready to urge on the Government at any time any reasonable mode of doing this, or of furthering independent inquiries.

Passing from pure science, he had a great share in the sanitary movement which has been so marked a feature of our days, although his name was not brought before the public so prominently as that of others who had really less influence. From a very early period he had been a very strong advocate of measures calculated to prevent disease and to improve the public health. He therefore used his influence with the Government to institute the Health of Towns' Commission, and those other early inquiries which were the foundation of the present movement. He was at this time intimately acquainted both with Andrew and George Combe, and estimated very highly the philosophical characters of the two brothers. Some years afterwards he edited and partly rewrote one of Andrew Combe's Hygienic works on the Management of Infancy.

At a very early date also, long before the Crimean war, he did what he could to get the sanitary state of the army and navy inquired into and remedied.

There can be no doubt that his service in the Navy had impressed him with the urgent importance of this subject, and had also given him a strong conviction of the waste of life in warlike operations.

Owing probably to their knowledge of his exertions in this direction, the Government during the Crimean war requested his cooperation in the organization of Supplementary Civil Hospitals, in support of the Military Hospitals, which were overflowing and had proved unequal to the work entailed by a severe campaign. He assisted in the deliberations which resulted in the establishment of the Smyrna Hospital; and subsequently, when a second hospital was required, the Government requested him to undertake the entire organization. He did so, and the result was the great Hospital of Renkioi on the Dardanelles, which was intended for 3000 sick. This hospital, the design of which was made by Mr. Brunel, has proved the model of the American Wooden Hospitals established during the late civil war, and indirectly has given rise to many of the arrangements in field hospitals in war which were carried out in Italy and Germany in the campaigns of 1859 and 1866, and are now being repeated on a still larger scale.

It was therefore not surprising that after the Crimean war he was asked to serve on the Royal Commission, presided over by Mr. Sidney Herbert, for inquiring into the health of the army; and he had no small share in

shaping the conclusions arrived at in that well-known and important inquiry. He subsequently took an equal interest in the Indian Sanitary Commission ; and it is really chiefly to his exertions and his influence with the Government (in support of the persistent action of Miss Nightingale, Sir Ranald Martin, Dr. Sutherland, and others) that we must attribute the advance which has been made in carrying out that most important reform, a reform which will influence not only the European soldiers in India, but the many million inhabitants of that empire.

It is not wished to claim for Sir James Clark more honour than is due. There were many other labourers in the field, and no one man unassisted could have done such great works. All that is urged for him is that he was one of the earliest of those who saw the importance of sanitary science, and that he was ever ready with time and thought and influence to aid in the progress of inquiry and reform. In connexion with military medical arrangements, he served on the Committee which organized the Army Medical School now stationed at Netley ; and he continued to the last moment to take the warmest interest in everything connected with that institution.

In addition to the work of inquiry on sanitary legislation among the civil population and in the public services, he was very much interested in the legislation for the insane. In 1855 an American lady, Miss Dix, who was visiting the lunatic asylums of England and Scotland, was refused admission into some of the private asylums in the latter country. In order to compass her wishes, she obtained introductions to some influential persons, among others to Sir James Clark, and the inquiries then set on foot led to the appointment of a Royal Commission to inquire into the Scotch Lunacy Laws. In this inquiry, and in the appointment of the Lunacy Commissioners which followed the Report of the Royal Commission, Sir James Clark took an active share ; and in after years, when various attempts were made to revert to the old state of things, he spared neither time nor trouble to stem the retrograde current by correspondence and verbal remonstrance with Members of Parliament and Members of the Cabinet ; indeed, after his death, the Lord-Advocate quoted in Parliament a letter from him as a justification of the foundation of the Scotch Lunacy Board.

Only two years before his death he wrote a life of Dr. Conolly, the object of which was not only to perpetuate the memory of his friend, but also to place before the public the true treatment of the insane, and to rebut the attempts, certainly feeble enough, which have been made to impair the wise and benevolent mode of treatment which Conolly did so much to popularize.

When it is considered that all these labours (and in the true sense of the word his exertions were labours) were carried on in addition to the work entailed by his Court duties and a large private practice, the great activity of Sir James Clark will be appreciated.

In this sketch only some of the public services rendered by him can be

referred to ; for his mode of using his influence was so unostentatious, and his desire for a recognition of his services so small, that much of what he did is scarcely known ; and the want of specific details in showing how his influence was brought to bear in so many ways is owing to the modesty of his nature. Justice, too, has hardly been done in the foregoing lines to his scientific knowledge and sympathies. In this respect, as in his constant endeavour to promote the wellbeing of his fellowmen, he was so little self-obtrusive that few men knew the extent of his acquirements. He paid, even to within a week of his death, constant attention to scientific progress, and especially to its practical application. Among his notes written but a few weeks before his last illness are details of the composition and mode of action of chloral. It was this union of a scientific spirit with great benevolence of character which, aided by a large experience abroad and at home, made him so excellent a physician.

His position at the Court necessarily occupied much of his time and thoughts ; he was unceasing in his attention to the health of the Queen and of her children, and the Royal family owe to him much of that blessing of health which has happily been their lot. He was on most confidential terms with the Prince Consort ; and the Prince found in him a congenial adviser on all points connected with education and science. The Queen's trust in him was early and firmly implanted, and was never impaired, and her sympathy and, we can truly say, affection for him were manifested to the last.

Sir James Clark retired from private practice in 1860, and removed to Bagshot Park, which Her Majesty had lent him for his life. He died there on the 29th of June, 1870, in the eighty-second year of his age, retaining almost to the last hour of his life a warm interest in all scientific progress, and a heart-felt sympathy with every step which would promote the improvement and happiness of his fellowmen.

WILLIAM ALLEN MILLER, Vice-President and Treasurer of the Royal Society, was born at Ipswich, in Suffolk, on the 17th of December, 1817. He was indebted for his early education to his mother, whose memory he cherished with the greatest love and respect, and whose quiet, sagacious nature was reflected in him. Mrs. Miller had a favourite maxim, "Take everything by the smooth handle ; and if a thing has not got a smooth handle, make one !" Dr. Miller was actuated through life by the spirit of this axiom ; and we have known him, when giving advice to a friend who sought it, introduce the remark, "Take it by the smooth handle."

Miller passed one year in Merchant Taylors' School, and two years at Ackworth, in Yorkshire, in a school belonging to the Society of Friends—the same in which Luke Howard took so great an interest that he purchased the Ackworth Villa estate, and made it his summer residence during some years. Luke Howard's partner, William Allen, F.R.S., the manufacturing chemist, and author, conjointly with Mr. Pepys, of the well-known researches

on respiration, was the friend after whom Miller was named. Miller's natural simplicity of character probably received its outward expression from this early contact with influential members of the Society of Friends. It was at Ackworth that he first distinctly remembered having acquired a taste for science, and a desire to devote his life to its cultivation; and this was not so much from the chemical lectures, or rather the chemical experiments, which were shown to some of the boys, as from the fact that Miller was occasionally invited to look at the stars through a telescope belonging to one of the masters. These early impressions bore fruit in the chemistry of the stars, with which his name is now associated. At the age of 15 he was apprenticed to his uncle, Mr. Bowyer Vaux, one of the honorary surgeons in the General Hospital at Birmingham, of which, during nearly twenty years, his father, Mr. William Miller, was secretary. After five years he entered the medical department of King's College, London, where his superior knowledge of chemistry over that of the other students attracted the attention of Professor Daniell, who more than once expressed his surprise in the inquiry, "Where did you get your knowledge from?" One of those opportunities that occur in the lives of most people, but are taken advantage of only by superior men, occurred in connexion with the chemistry lectures. Miller had no taste for surgical practice, and preferred, if possible, to get some employment in the laboratory of a manufacturing chemist, rather than become a medical practitioner. Indeed he did perform some analyses for the Messrs. Chance, while in treaty with them for more permanent employment. But the laboratory assistant at King's College having been disabled by illness, Daniell engaged the services of Miller; and when the office of Demonstrator in the laboratory became vacant in 1840, he was appointed to the post. It should be mentioned that in 1839 Miller obtained the Warneford Prize for the encouragement of theological studies among medical students, and in 1840 he passed a few months in Liebig's laboratory at Giessen. In 1841 he became Assistant Lecturer for Professor Daniell, and also took his degree of M.B. in the University of London, proceeding to M.D. the following year. He also assisted Professor Daniell in various scientific inquiries, and conducted the experiments on the electrolysis of saline compounds, his name being associated with that of Daniell in the paper that appeared in the *Philosophical Transactions* for 1844. In the following year he was elected a Fellow of the Royal Society, and on the death of Professor Daniell succeeded to the vacant chair of Chemistry in King's College. The writer of this notice was engaged in assisting Professor Daniell to bring out the third edition of his well-known work entitled "*Meteorological Essays*," and on the sudden death of the author he requested Dr. Miller to cooperate with him in completing the work, to which he readily assented. Dr. Miller was engaged about this time in some experiments on Spectrum Analysis. They were conducted in a sort of lumber-room below the seats of the Chemical Theatre, and formed the subject of a paper which was

read before the British Association and published in 1845 in the *Philosophical Magazine* (Series 3, vol. xxvii. p. 81). He thus became interested at an early period in the subject of spectrum investigation.

Miller continued during some years to use as his text-book Professor Daniell's 'Introduction to the study of Chemical Philosophy,' supplemented at a later period by Fownes's 'Manual of Chemistry.' The writer of this notice repeatedly urged Dr. Miller to bring out a work of his own, which should be better suited to the wants of his pupils; but he hesitated in doing so lest he should at all interfere with his predecessor's work. "I must prepare the book," he said, "from my lecture-notes, and you are not aware how much of Daniell I have in them." For some time his idea was to accede to a proposal of the publisher of Daniell's work to bring out a third edition, making such additions thereto as the progress of science required, and to maintain it in its old position as the text-book. But on looking over Daniell with this view, he found that so many additions and alterations would be required as greatly to supersede the author's peculiar touches; so that he finally decided to produce a new work, and the first volume accordingly appeared in 1855. In the preface to this volume, which was devoted to "Chemical Physics," the author stated that "he had decided to leave untouched the work of his late master, as the true exponent of his views, upon some of those branches of science which his researches had contributed to advance and adorn." The two subsequent volumes on "Inorganic" and "Organic Chemistry," which appeared, the one in 1856 and the other in 1857, were written from Miller's lecture-notes, as was also the case with the "Chemical Physics," the notes being so amplified as to form continuous reading, a process which led to so many insertions and alterations as to make the manuscript difficult to read. But the effect of this mode of treatment was so far advantageous that when the books were introduced to the students, they, so far from having to conform to any new method, seemed to recognize in the new text-books the very lectures they had heard.

The three volumes of Miller's 'Elements of Chemistry' passed through several editions, and were reprinted in the United States of America. While not professing to set forth any marked original views, the work affords a clear and comprehensive exposition of the science, and soon became deservedly popular. In the later editions Miller adopted the new method of notation in chemistry. His conservative principles led him to resist this change as long as it was possible to do so. Moreover, having been, during so many years, accustomed to the old notation, he never took kindly to the new. Indeed it was part of Miller's character to grasp a new idea with a certain amount of mental slowness; but when once fairly appreciated, it was held tenaciously and not given up without a severe struggle. But he was so conscientious that he would sacrifice every thing to what he held to be the truth. The writer has known him to refuse to hold any further intercourse with a foreign man of science whom he had received into his

house and assisted in various ways, on hearing the expression of a doubt as to the benevolence of the Almighty for permitting him to undergo so much trouble. Soon after he became Professor, he was on one occasion giving evidence in a court of law on some scientific point connected with a patent, when, during the cross examination, the Judge made a remark which had the effect of questioning the veracity of the witness. Miller felt this so keenly that he fainted, and had to be carried out of court. After a short interval the Judge sent to inquire how he was. Miller said, "I shall be better when his Lordship does me justice." On his return, the counsel for the cross examination was proceeding to put questions in the spirit of the objection, when the Judge stopped him, stating that he had misunderstood the witness, and explained how.

As a lecturer Miller was more successful in style and expression than as a writer, for his written composition had some tendency to become involved. One of the best specimens of his lectures is that on Spectrum Analysis, given before the British Association at Manchester in 1861, at the time when Kirchhoff's researches had made the subject more than usually popular. One part of this lecture was devoted to an historical review of that remarkable branch of chemico-physical research; and so little attention had been paid to this part of the subject that when a large audience were collected to hear, as they supposed, an account of Kirchhoff's discoveries, they were not a little surprised to find Kirchhoff occupying the end of a long series of illustrious names, from Newton in 1701 to Wollaston in 1802 and Fraunhofer in 1815; while the various other names were arranged after the fashion of a genealogical tree, under the four heads of (1) Cosmical lines, (2) Absorption-bands, (3) Bright lines produced by the electric spark, and (4) by coloured flames, the four branches uniting in the names of Kirchhoff and Bunsen, 1860. On the morning of the day appointed for that lecture, successful and brilliant as it was, Dr. Miller was seized with one of those bilious attacks to which he was subject, and was so prostrated that he had to keep his bed nearly up to the time of the lecture, and return to it immediately after its close. This gave occasion to a little incident which deserves to be noted as illustrative of the cautious habit of forethought of the man. In moving to the front of the crowded platform with a bottle containing red nitrous fumes in his hand, in his weak state he stumbled and fell, breaking the bottle in pieces. Immediately he sprang to his feet, exclaiming "I have another!" on which a round of applause caused him to remark, as if to himself, "I am too old a lecturer to rely upon one bottle."

This lecture was repeated before the Pharmaceutical Society of London on the evening of the 15th January, 1862, and printed in the Society's Journal for February of that year. The historical details given in it have been largely used by subsequent writers, presenting, as they do, in a very clear manner, the results obtained by the earlier workers on the Spectrum. It was on returning from this lecture to his house at Tulse Hill, with his

friend and neighbour Mr. (now Dr.) Huggins, that Miller assented to a proposal made by Mr. Huggins that they should unite in carrying on a series of experiments on the spectra of the heavenly bodies. Miller was at this time engaged in an elaborate series of experiments which formed the subject of a paper read before the Royal Society, 19th June, 1862, "On the Photographic Transparency of various bodies, and on the Photographic effects of metallic and other Spectra obtained by means of the Electric Spark." This paper is inserted in the Philosophical Transactions for 1862.

The joint labours of Miller and Huggins were continued during about two years; and as the observations could only be made at night, they must have told on the energies of a man who was so actively employed as Miller in brain-work at College and elsewhere during the day. The first results of their observations are given in a note on the lines in the spectra of some of the fixed stars, dated February 1863\*, from which it appears that a considerable time was devoted to the construction of apparatus suited to this delicate branch of inquiry; but they had at length "succeeded in contriving an arrangement which has enabled them to view the lines in the stellar spectra in much greater detail than has been figured or described by any previous observer." They further add that, "during the past twelve months, they have examined the spectra of the Moon, Jupiter, and Mars, as well as of between thirty and forty stars, including those of Arcturus, Castor,  $\alpha$  Lyræ, Capella, and Procyon, some of the principal lines of which they have measured approximatively. They have also observed  $\beta$  and  $\gamma$  Andromedæ,  $\alpha$ ,  $\beta$ ,  $\epsilon$ , and  $\eta$  Pegasi, Rigel,  $\eta$  Orionis,  $\beta$  Aurigæ, Pollux,  $\gamma$  Geminorum,  $\alpha$ ,  $\gamma$ , and  $\epsilon$  Cygni,  $\alpha$  Trianguli,  $\epsilon$ ,  $\zeta$ , and  $\eta$  Ursæ Majoris,  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\epsilon$ , and  $\eta$  Cassiopeiæ, and some others." When their labours were sufficiently advanced, they embodied their results in a memoir entitled "On the Spectra of some of the Fixed Stars," which was published in the Philosophical Transactions for 1864. At a somewhat later period there is a joint note on the spectrum of the variable star Alpha Orionis, contained in the 'Monthly Notices of the Royal Astronomical Society,' vol. xxvi.; and another joint note on the spectrum of a new star in Corona borealis, in the 'Proceedings of the Royal Society,' vol. xv., dated May 17, 1866.

Messrs. Miller and Huggins, for their "conjoint discoveries in Astronomical Physics," received each the Gold Medal of the Royal Astronomical Society; and on the occasion of presenting these medals, the President, the Rev. C. Pritchard, M.A., F.R.S., after referring to a former inquiry as to "What is a sun?" remarked that the progress of science had led to the further query, "What is a star?" "For the first dawning of a distinct and intelligent reply to this question we are indebted to Messrs. Huggins and Miller." \* \* \* We find them associated "in the examination of the spectra of stars by means of an admirable and newly contrived apparatus which had required much thought and labour to construct. With this

\* Proceedings of the Royal Society, vol. xii. p. 444.

instrument attached to the telescope it was possible not only readily to divide the sodium line D into its two compartments, but to exhibit also the nickel line which Kirchhoff had observed between them. The spectra of the stars were now, in the first instance, compared approximately with the superposed atmospheric spectrum already alluded to, for the purpose of suggesting what metallic lines probably existed in the star under observation, and then were compared directly, by actual juxtaposition, with the actual spectra of those metallic vapours which had been already suggested. It seems impossible to conceive any process more rigidly or conscientiously exact than that which Messrs. Huggins and Miller thus skilfully adopted; and here I may be excused for repeating that the attainment of the ultimate object of the research depended, not on any approximation, however close, of the stellar with the metallic spectra, but on the certainty of their absolute coincidence. In this way, during the space of two years and a quarter, many of the midnight hours of these gentlemen were passed in the scrupulous examination and measurement of the spectra of upwards of fifty stars; but in several instances the number of the fine dark lines, the inevitable indices (be it remembered) of the material constitution of these distant worlds, were so numerous, that to measure and map them all the labour of months would barely suffice. The physical result of all this scrupulous and conscientious care was to discover the fact, or it may be to confirm the suspicion, that those mysterious lights with which the firmament is spangled are in strict reality worlds fashioned, in their material constitution at least, not altogether differently from the fashion of the little orb on which we live; beyond the question of a doubt they are proved, by the investigations of our medallists, to contain at least the hydrogen, the sodium, the magnesium, the iron with which all terrestrial creatures are so familiar."

On Tuesday, May 14th, 1867, Miller commenced at the Royal Institution a course of four lectures on "Spectrum Analysis, with its applications to Astronomy." These lectures were reported in the 'Chemical News,' under the revision of the author. Again, at the Meeting of the British Association at Exeter in 1869, he gave a lecture on Spectrum Analysis to working men. This lecture was afterwards published in the 'Popular Science Review' for October 1869.

Miller was interested in the subject of water analysis, and, in conjunction with Professors Graham and Hofmann, prepared a Report for the Government "On the Chemical quality of the Supply of Water to the Metropolis." This was printed in 1851. At a later period he undertook an investigation "On the combined Action of Air and Water on Lead," and in 1865 gave a lecture before the Chemical Society "On some points in the Analysis of Potable Waters."

Quitting the subject of Miller's original work, we pass on to a brief notice of the various services rendered by him to Science. He was on the Council of the Royal Society during the years 1848-50 and 1855-57,

and being elected Treasurer on the 30th of November, 1861, he served on the Council in an official capacity till the time of his death. His methodical and punctual habits, his knowledge of affairs, and his excellent judgment, with the earnest and lively interest he took in the welfare of the Society, rendered his special services as Treasurer of the utmost value; whilst the same high qualities, combined with his accomplishment in science, singularly well fitted him for the various duties he had to perform as Member of the Council and a chief Officer of the Society. The date of his election to the Fellowship is 1845.

Mr. Gassiot, who knew Miller intimately, referring to his merits as Treasurer, writes, "a more straightforward officer, or one more devoted to upholding the dignity and promoting the usefulness of the Royal Society, I do not know; and there is probably no one with whom Dr. Miller communicated on the subject so freely as myself." Mr. White, the Assistant-Secretary, who habitually had to transact business with him, adds, "My own experience of Dr. Miller was, that on walking down to King's College I could tell beforehand the mood in which I should find him—always uniform and considerate. His decision on questions brought before him was generally quick and sound, and he was ready in detecting the weak points of an argument. In the whole period that he was Treasurer I never had a single disagreeable word with him."

In 1866 Dr. Miller was nominated a Member of the Committee then appointed for the purpose of superintending the Meteorological Observations made by direction of the Board of Trade, and served on it till the time of his death; he was also an active Member of the Committee of the British Association for superintending the Kew Observatory, and devoted much time to that work. The definition of the arrears to be executed under the superintendence of Mr. Balfour Stewart, as entered on the Minutes of the Committee, 9th March, 1870, was written by and inserted at Dr. Miller's particular request, in order specially to define the important work that has yet to be completed by the time when the connexion of the Observatory with the British Association shall cease.

It may here be mentioned that whilst a Member of the Committee appointed to advise on the scientific arrangements for the marine researches carried on during the voyage of the 'Porcupine' in 1869, Dr. Miller was happy enough to contrive a thermometer adapted for taking deep-sea temperatures, which has been found admirably to fulfil its purpose\*.

Miller was one of the original founders of the Chemical Society, and frequently presided over its meetings, as well as occupied a place at its Council Board. Along with his other various occupations, Dr. Miller was a Member of the Senate of the University of London, to which he was appointed, on the recommendation of Convocation, early in 1865; and his sound judgment and knowledge generally, as well as his accomplishment in chemical and physical science and his experience as a teacher, gave

\* Proceedings of the Royal Society, vol. xviii. p. 408.

great weight to his opinion in the deliberations of that body, and caused his loss to be severely felt.

In addition to the various honours which rewarded Miller's position as a scientific man, it should be mentioned that he received the degree of LL.D. at the University of Edinburgh, on the occasion of the installation of Lord Brougham as the first Chancellor, that of D.C.L. at the University of Oxford in June 1868, and that of LL.D. at the University of Cambridge in May 1869, after giving the Reade Lecture, which on this occasion was on the Coal-tar Colours.

Perhaps the most marked feature in Miller's character was sagacity combined with a deep sense of religion. His religious views may be gathered, although imperfectly, from an address entitled "The Bible and Science," delivered at the Church Congress in Wolverhampton, October 3rd, 1867; also from his "Introductory Lecture," on the opening of the Medical Session at King's College, October 1st, 1859, published under the title, "Hints to the Student on commencing his Medical Studies."

In conclusion, the writer may be allowed to repeat what he said in a short notice at the period of Miller's death, drawn up at the request of the editor of the 'Chemical News':—"During a quarter of a century Miller continued to lecture with unceasing activity, and to take part in the management of King's College, every one, from the Principal and Professors to the youngest student, being anxious to obtain his advice and assistance. It was impossible to come in contact with him without feeling one's self in the presence of a man of pure nature, of spotless integrity, of sound and sagacious judgment, and of true gentlemanly feeling. His loss will be deeply felt, especially in King's College, in the Royal Society, in the Mint, and the Bank of England, where he was one of the Assayers. He will be missed in the Courts of Law, where his clear perception of patented processes, and his strong sense of justice, made him respected alike by judge and counsel. He will be missed by the manufacturers who sought his advice; but, above all, he will be missed by his own family, and by the few friends who had his confidence."

There had been symptoms of an overwrought brain for some months previous to his last illness, which took place on the journey to Liverpool, 13th September, 1870, at the time of the British Association gathering, which, however, he was unable to attend, his illness culminating in apoplexy on the 30th of the same month. His remains were brought from Liverpool and interred in the cemetery at Norwood, by the side of those of his wife, whom he survived one year. He died on the anniversary of her burial, and at the comparatively early age of 53. He married, in 1842, Eliza, eldest daughter of the late Mr. Edward Forrest, of Birmingham, by whom he leaves issue, two daughters and one son.—C. T.

JOHN T. GRAVES, M.A., F.R.S., was son of John C. Graves, of Dublin, Barrister-at-Law. He was born in Dublin on the 4th of December, 1806, and passed some years in the school of the Rev. Samuel Field, Westbury-on-Trym, Somersetshire. He entered Trinity College, Dublin, in 1823, and was a class-fellow of Sir William Rowan Hamilton, with whom, though living at a distance, he kept up a life-long friendship. In his undergraduate career he was distinguished in both Science and Classics, and at his Degree Examination in 1827 was awarded the Classical Gold Medal. He soon after took an *ad eundem* degree at Oxford, and was incorporated in Oriel College, where he resided some time, and proceeded to the degree of M.A. He was also M.A. of Dublin University. On the 10th of June, 1831, he was called to the Bar as a Member of the Inner Temple, and for a short time went the Western circuit. In the year 1839 he was appointed Professor of Jurisprudence in University College, London, in succession to Mr. Austin, and not long after was elected to be Examiner in Laws in the University of London. The records of his work as a lawyer are Twelve Lectures on the Law of Nations, published in the 'Law Times,' commencing April 25, 1845, and two elaborate articles contributed to the 'Encyclopædia Metropolitana,' on Roman Law and Canon Law. About this time he was a contributor to Smith's Dictionary of Greek and Roman Biography and Mythology. Among other articles from his pen are those on Cato, Crassus, Drusus, Gaius, and the Legislation of Justinian.

As a scientific author Mr. Graves commenced his labours in his twentieth year. It was in October 1826 that he was engaged in researches on profound and subtle questions in analysis; the results he obtained were communicated to the Royal Society of London in the year 1828, and published in the Philosophical Transactions for 1829, under the title "An attempt to rectify the Inaccuracy of some Logarithmic Formulæ." This paper gave rise to interesting and important discussions, with which the names of M. Vincent, Peacock, Ohm, De Morgan, Warren, Rowan Hamilton, and others are connected. It was by meditating upon the results of this memoir that Sir W. Rowan Hamilton was led to his ingenious theory of Conjugate Functions or Algebraic Couples, as may be learned from Sir W. R. Hamilton's abstract of a paper "On Conjugate Functions, or Algebraic Couples, as tending to illustrate generally the Doctrines of Imaginary Quantities, and as confirming the Results of Mr. Graves respecting the existence of two Independent Integers in the complete expression of an Imaginary Logarithm," as well as from an abstract of a "Memoir on the Theory of Exponential Functions," both published in the Report of the British Association for 1834. In continuation of the same and allied researches, Mr. Graves contributed a paper to the Philosophical Magazine for April 1836, "On the lately Proposed Logarithms of Unity, in reply to Prof. De Morgan;" and in November and December of the same year another, entitled "Explanation of a remarkable Paradox in the Calculus of Functions, noticed by Mr. Babbage." To the same journal were contri-

buted by him, in September 1838, a New and General Solution of Cubic Equations; in August 1839 a paper on the Functional Symmetry exhibited in the Notation of certain Geometrical Porisms when they are stated merely with reference to the arrangement of points; and in April 1845 a paper on a Connexion between the General Theory of Normal Couples and the Theory of Complete Quadratic Functions of Two Variables. A subsequent number contains a contribution on the Rev. J. G. MacVicar's Experiment on Vision; and the Report of the Cheltenham Meeting of the British Association contains abstracts of papers communicated by him on the Polyhedron of Forces, and on the Congruence  $nx = n + 1 \pmod{p}$ .

The above list of papers, itself incomplete, is far from representing adequately Mr. J. T. Graves's contributions to mathematical science. The Transactions of the Royal Irish Academy contain many traces of his intellectual activity; and by his long correspondence with Sir William Rowan Hamilton, commenced at an early period and maintained until death interposed, Mr. Graves may be said to have taken no small part in bringing to maturity the splendid conception of Quaternions, by which alone the name of Hamilton would have been rendered immortal. In his preface to the 'Lectures on Quaternions,' Sir William makes frequent allusion to the suggestive character of his correspondence with his early friend, and warmly expresses his indebtedness thereto.

Mr. Graves was one of the Committee of the Society for the Diffusion of Useful Knowledge. In the year 1839 he was elected a Fellow of the Royal Society, and he subsequently served upon its Council. He was also a Member of the Philological Society and of the Royal Society of Literature.

For many years past he had taken interest in forming a collection of mathematical works of all ages and countries, a collection which, though only to be appreciated by the few, is by those qualified, who are acquainted with it, considered to be almost unique for historical curiousness and completeness; and nearly every book composing it was bound under his direction with costly care and elegance. This portion of his library he bequeathed to University College, London, in remembrance of his former connexion as Professor with that Institution.

In the year 1846, soon after his marriage with the daughter of the late William Tooke, Esq., F.R.S., he was appointed Assistant Poor-Law Commissioner, and on the constitution of the present Board in 1847 was made Poor-Law Inspector. He served efficiently in that department till the past month, when he sent in his resignation, an act which he did not long survive. He died on the 29th of March, at his residence in Cheltenham, at the age of 63.